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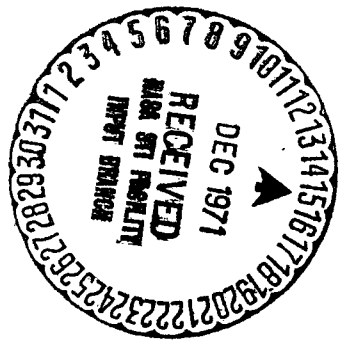

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ABSTRACT: The sequence of failures in the "Europa" rocket program is analyzed from the standpoint of determining the course of future action. It is felt that in view of the commitments already made and the disruption of industry and employee layoffs that a suspension of the program would entail, the program would proceed, perhaps at an accelerated pace. The reasons for the F-11 failure are given.

The failure of the eleventh launching of the Europa rocket poses a difficult problem for those who support the space program in Europe. Already, certain German sources estimate that the contribution of the R.F.A. [Note: expansion not available] to CECLES-ELDO can only be continued if the leadership of the European organization is seriously changed: the French position would be quite close to the German one. On the occasion of the meeting of CECLES-ELDO which is to take place this Thursday (18 November) the question might very well be asked in an effort to find out if a reorganization in depth might not be desirable. /20*

Put this way, the problem appears simple, too simple in fact: if the rockets do not work, it is because the organization is bad; so let us change the organization. It happens that the departure of the Secretary General of CECLES-ELDO, Ambassador R. Di Carrobio, simultaneously involves the designation of the new Secretary who must be named on the 18th of November and the departure of a portion of the staff of the organization[1] which must also be replaced. It is only one step from this to concluding that once it has been given a new leadership, CECLES-ELDO will function in a satisfactory manner and its rockets will do the same: such simple reasoning, however, involves the risk of concealing both the truth and the responsibilities which do not rest firmly at the level of the European organization.

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*Numbers in the margin indicate pagination in the foreign text.

[1]Chief Engineer Girardin, Technical Director of CECLES-ELDO, and M. H. Costa, Administrative Director.

Rocket Without Mastery of the Work

If the Europa rocket as it exists today is really a relatively nondescript collection of "National" stages developed on an individual basis, the fault rests primarily on the political concept which prevailed when CECLES-ELDO was born. The British contribution was in the form of the "Blue Streak:" France agreed to furnish the second stage, and Germany the third. The European Organization was there only to build the rocket out of elements whose mastery escaped it nearly completely. The course of events has demonstrated that this multinational "Erector set" has led to an increase in delays as well as costs, in addition to a doubtful reliability of our operation. However, it would be unfair to hold responsible those who were entrusted with the task of somehow making an incoherent system function: those who are really responsible are the men who imposed or accepted ten years ago the task of developing a multistage rocket without accepting the necessary corollary; the creation of a pilot organization which would be responsible (once the program was started) for guiding the operation, drawing up agreements, performing quality checks, etc. The most unusual thing is that previously the SEREB organization had been formed in France, which was intended precisely for the task of serving as the architect for future ballistic missiles in the "Dissuasion Force." We could go on at great length about the successful ballistic program and the failure of the European organization. Two years ago, an internal reaction took place: CECLES--ELDO finally obtained the right to deal directly with industries with the assistance of SETIS (Société Européenne d'Etudes et d'Intégration de Systèmes Spatiaux) [European Society for Study and Integration of Space Systems] whose role has increased, and a "Direction des Activites Futures" (D. A. F.) [Future Activities Management] was set up, and trusted both with directing the construction of the Europa II rockets in the series and studying the Europa III program. At the same time, a critical study of the two rockets (Europa I and Europa II) was launched ("Design Review") which led to a number of changes being decided on and carried out. Some were incorporated in the rocket which was used for the F-11 launching on 5 November, which led to the explosion of the first stage after 150 seconds. Thus, the first stage, which had been fired successfully 10 times, was the oldest element and the one that was considered most reliable in the rocket...

Give Up or Continue

Obviously, there is reason to ask now whether the Europa II rocket will ever decide to function completely someday: evidently, three policies are open:

--continuation of the current effort within the framework of the renovated organization:

--give up the Europa II program and devote all effort to the Europa III program,

--give up both programs and simply dissolve CECLES-ELDO.

We have mentioned the third alternative only for the sake of completeness: it would mean that the seven member states of the organization would be admitting to the $641,000,000 (3.5 billion francs) which have been spent thus far have been completely wasted, without even attempting the F-12 launch planned for April 1972: the rocket to be used for this launching has already been built and is on its way to CSG (Centre Spacial Guyanais) [Guiana Space Center]. No savings would be achieved by not firing it...

There are some people who support the second view. However, there are two major obstacles to this solution. The first is the fact that two "Symphonie" satellites are actually under construction, and would have to be launched in 1973-1974. The construction of the required launchers (F-13 and F-14) was decided on and started in 1970, and stopping this project, in view of the penalties to be paid totthe industries and the personnel who would be laid off, would probably not involve any substantial savings. Better still: in view of the very long fabrication time for a rocket (more than 2 years) and the need to provide three years in advance certain long-term provisions (for example, the special tubes with decreasing cross-section which make up the cooling system for the nozzles), the F-15 and F-16 launchers have also been started and the first long-term orders have been placed for the F-17 and F-18 launchers...

In our opinion, the second obstacle is much more serious, because it is critical to the future of the European launchers. The development of a rocket is primarily a question of men and technical capacity, or more exactly, experimental equipment and industries sufficiently equipped with design offices and methods of production and testing.

This means that in order to be able to work and persevere, the technicians must feel that they are supported, in other words, they must not be worrying about their future at every moment. This applies on a short-term as well as a /21
long-term basis. Already, there is a certain degree of discouragement evident among the engineers (and not the least important of them) while working on the Europa II program. Can you imagine what would happen if this program were abandoned? It would mean that the best technicians, those who are working precisely on their careers would have to accept a waiting status, in a state of uncertainty, to await the Europa III program, which is still only a project... Likewise, the industries would not be able to keep their research and testing groups as well as their design offices on a standby basis, and they would be practically dissolved. Then what would happen to the Europa III rocket?

This problem is especially serious in view of the contracts that were signed to permit continuation of the work and appropriations for the F-15 1a launchers that were drawn up "to ensure continuity of the production cycle in industry:" this is taken from the annual report to the council of Europe from CECLES-ELDO.

Hence, practically speaking, the realization of the Europa III program means that the Europa II program must be carried out: the two form a whole: if nothing else, this would make it possible to avoid making mistakes on the Europa III which could be caught by those working on Europa I and II. Experience is the most difficult thing in the world to transmit...

Insufficient Tests

Hence, we are left with the first choice, i.e., continuing the current effort. But in what form?

Before the F-11 shot, the "qualification" of the Europa II launchers was planned to be accomplished with two shots, F-11 and F-12.

We say "planned," as a matter of fact, since 1970, it has become quite /22
risky to count on achieving qualification with only two shots:

--that of the fourth stage (perigee motor), although the latter is derived directly from the third stage of the Diamant B;

--that of the new safeguard system, in accordance with the requirements of CSG, which allows safeguard, destruction and motor shut-off signals to be transmitted to the first three stages from two telecommand receivers mounted on the second stage:

- that of the electrical supply system, now supplied to all stages by batteries:

- finally and in particular, that of the inertial guidance system (mounted in the third stage), which replaces the old radio-guidance system and supplies the autopilots of the first three stages with the information. Built by GEC-Marconi Electronics with the collaboration of Ferranti and four other companies (Dutch, Italian and German), this system has already undergone its first flight test in the F-9 launching, but merely as a payload which emitted signals that were not used.

Hence, an additional test firing was scheduled (on an optional basis) for the F-13 launcher. In this case, the first "Symphonie" satellite could still be launched on a planned date with the F-14 launcher and the second "Symphonie" with one of the following launchers.

After the failure of the F-11 shot, regardless of what the causes were, the use of the F-13 laucher appeared necessary in order to subject the Europa II launcher to at least two sucessful qualification firings for its operational use. Better still, the first "Symphonie" could then be launched by the F-14 and perhaps even the F-15.

The decision to use the F-13 launcher (even the F-14), for one or two additional qualification shots would also have certain advantages, especially as far as the scheduling of the shot was concerned: the F-9 shot took place at Woomera in June 1970. The F-11 shot was scheduled for 1971 at the CSG, and the F-12 would be fired in the spring of 1972. Hence, there would be a long interval between F-12 and F-13, the latter being scheduled for the end of 1973. The slightest shift (which could not be excluded) in the schedule of Symphonie launchings could even lead to a complete absence of shots in 1973.

This is an unhealthy situation: first of all, for the crews working on the Europa II, who would be forced into inactivity that would lead to disinterest and even discouragement: it would also be unhealthy for the industries, which would be obliged to operate at a very slow rate of production: it would be bad for the economics of the operation, since the staggering of the program time would be translated into false economies since the crews would be standing by and the equipment would be depreciating poorly: finally, it would be bad for the CSG, whose facilities (whether they belong to ELDO or not) are underutilized, which is never a good thing for complex and delicate equipment. The latter point must not be underestimated, especially at a time when the excellent operation of the CSG installations has earned unanimous applause.

Should the Sequence of Launchings be Stepped Up?

Hence, it appears that stepping up the sequence of shots is desirable. As paradoxical as this might seem in the current situation, this decision would at least have the advantage of reinforcing the confidence of the technicians in the future of the European launcher program and very likely in its feasibility as well. The talks which we have had with certain responsible individuals, before as well as after the F-11 shot, proved in effect that the current schedule for firings, at least one launching per year, is incompatible with a rational operation of the program. This extremely slow firing schedule may even explain the successive failures or semifailures in the Europa I-II program: it is the savings which cost dearly, and CECLES-ELDO may now perhaps be suffering from the backlash of decisions that were made several years ago when deep cuts were made in the number of firings which were judged necessary. Of course, pressing financial reasons were given at the time to justify this drastic limitation. From the vantage point which we have today, there is some doubt that all of the decisions that were made were particularly wise: an additional firing of the Europa II rocket would actually save a hundred million Francs. We can then see that if the "G" firings (2) were increased to six as originally planned and if the three-stage "F" launchings were made at the rate of 3 or 4 per year since 1966, as was quite possible, the increase in expenditure which would have been involved by a doubling of the number of useful tests would probably not have exceeded 500 to 600 million Francs, in other words, a sixth of the

total budget. Even now, each additional shot represents only 3% of the total expenditure.

Is this exaggerated optimism on the part of the technicians? A lack of perception on the part of governments, eager for economy at any price? It is difficult to say for sure. We can simply point out that the seven successful shots of the "Diamant" were preceded by several dozen firings of single or two stage rockets ("Emeraude", "Saphir", "Topaze", "Rubis"). It would be a mistake, we believe, to say now that the Europa rocket will never work because its first stage has exploded after 10 consecutive firings: making a severe cut in the number of qualification tests amounts to making one more. And to admit, as is being done at the present time, that the construction and qualification of the future Europa III launcher could be accomplished in five shots, in our opinion, merely amounts to a form of dangerous optimism. It is not by economizing at any price, as far as a number of tests is concerned, which will allow the governments to achieve a rational European space policy. The most serious error would be to continue with this policy: will the new leadership of CECLES-ELDO have the necessary weight to be able to admit to the responsible politicians that a drop in the restrictions is necessary? At the point where we are now, there are really only two solutions: to give up the construction of satellite launching rockets or to initiate serious reevaluation of the current programs. It is more than a question of reorganization of CECLES-ELDO: it is a question of confidence and of means.

The F-11 Shot: The Mystery is Explained

The technicians now know why and how the Europa II rocket which was launch-on 5 November at Kourou was destroyed by two explosions that occurred 150 and 160 seconds after launching.

The logical connection which links the two principal known facts is as follows: the failure in the control signals coming from the inertial guidance system took place at 107 seconds followed by the first "explosion" that took place at 150 seconds (1) is actually established; at 107 seconds, the rocket shifted, assuming a greater and greater degree of incidence in its trajectory. This incidence is normally nearly 0 degrees; the Europa II eventually attained

an incidence of 35 degrees. Subjected to abnormal aerodynamic stresses and asymmetric kinetic heating, the rocket broke in two with the break occurring between the first and second stages, i.e., at the level of the interstage truncated skirt.

The first result of this break was a collision between the two stages; this certainly led to a rupture of the structural tank containing liquid oxygen in the first stage. As far as the second stage is concerned, it was probably considerably shaken up so that a crack appeared at the level of the hemispherical diaphram which separates the nitrogen peroxide tank from the U.D.M.H. [Note: expansion not available] reservoir: the two ergols being hypergolic, the contact between them released a chemical reaction which led first to a rise in pressure in the reservoirs and then to an explosion which showed up quite well on the pictures taken by cinetheodolite.

We should note in passing that a rocket is obviously designed to withstand the aerodynamic stresses which are imposed when passing through the lower layers of the atmosphere; as it rises and accelerates, these stresses begin to increase with the increasing factor which represents in the expression for the dynamic pressure the square of the velocity outstripping the decreasing factor of the specific mass of the air. The aerodynamic stresses (complicated by the phenomenon of compressibility) thus pass through a maximum, approximately 67 seconds after the lift-off in the case of Europa II.

Then the rarefaction of the air increases and the dynamic pressure decreases slowly, but falls to zero at a much slower rate; this is the reason why in the case of Europa II the shield designed to protect the satellite is not released until 220 seconds after lift-off, at an altitude of 120 kilometers, when the velocity is more than 4200 meters per second.

Matters are evidently quite different when the rocket is not parallel to its velocity vector, i.e., tangent or practically tangent to the trajectory. At high incidences, as in the case after the F-11 shot, the aerodynamic forces can become much more significant, even at high altitude; kinetic heating aggravates the situation, and this heating becomes increasingly important as the rocket attains greater incidence and the point of arrest, normally confused with the point ahead of the rocket, shifts toward the rear.

We still must determine why the inertial guidance system ceased emitting its piloting signals; these signals actually come from a digital computer associated with the inertial platform. The analysis of the telemetric recordings has shown thus far that 3 malfunctions occurred at 107 seconds; one took place at the level of the inertial guidance, the second at the level of the third stage sequencer and the third at the level of a sensor, likewise in the third stage.

Were theseffailures related, and if so, which was first? The answer is not easy to find, because the three phenomena were picked up during periods of digital telemetrywwhich overlap. The technicians thus,will probably have to simulate on the ground this series of failures in order to understand what happened.

It should also be noted that one of the sensors on the rocket appears to have recorded a vertical vibration ("POGO" at a low level) which was more severe than predicted. The responsible equipment was contained in modules attached to the internal wall of the ad hoc compartment, and we could suppose that the vibrations had some kind of harmful effect on their function; but this is only a hypothesis which still lacks any precise foundation.

In any case, the technicians are reassured; the general phenomenon having been identified, they now know where their efforts must be directed; it is certain equipment in the inertial guidance system or the third stage which must be checked out. The speed with which the diagnosis was made should also be emphasized.

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